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Working Level Screening Survey of Structures Constructed of Materials Containing Pumice

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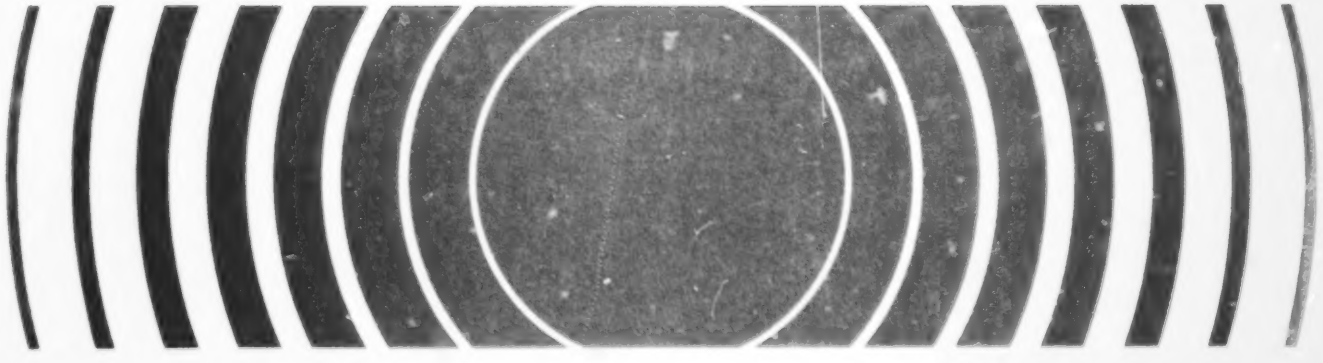

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16. ABSTRACT

This report describes the results of a screening survey conducted in several northern New Mexico communities to estimate the levels of radon progeny (working levels) in building, constructed of materials containing pumice. This locally-produced material is used as a lightweight aggregate in concrete blocks, and contains slightly elevated levels of natural radionuclides.

The screening survey results indicate that the use of pumice block may increase the working level in the structure, although the effect is so small that it is difficult to separate it from background variations and from the variability caused by other parameters.

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WORKING LEVEL SCREENING SURVEY OF STRUCTURES CONSTRUCTED OF MATERIALS CONTAINING PUMICE

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PREFACE

The Office of Radiation Programs of the U.S. Environmental Protection Agency carries out a national program designed to evaluate population exposure to ionizing and nonionizing radiation, and to promote development of controls necessary to protect the public health and safety. This report describes a preliminary evaluation of radon progeny levels and gamma radiation levels in buildings constructed partially or entirely of block in which pumice, having slightly elevated radioactivity levels, was used as aggregate. Readers of this report are encouraged to inform the Office of Radiation Programs of any omissions or errors. Comments or requests for further information are also invited.

Donald W. Hendricks

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WORKING LEVEL SCREENING SURVEY OF STRUCTURES CONSTRUCTED OF MATERIALS CONTAINING PUMICE

INTRODUCTION AND BACKGROUND

Pumice, produced from open pits northwest of Santa Fe, New Mexico, is widely used throughout the southwest as a lightweight aggregate for making concrete blocks. This pumice is known to have a slightly elevated concentration of the naturally-occurring uranium decay chain radionuclides. Consequently, a potential exists for radiation exposure from radon* progeny to people living or working in buildings which contain this material.

This matter first came to the attention of the Office of Radiation Programs - Las Vegas Facility (ORP-LVF) during the decontamination of the inactive uranium mill site at Shiprock, New Mexico. Radon progeny levels (working level)** were monitored extensively in a training building near the site, and were found to be significantly elevated, averaging greater than 0.02 WL (net above background) on an annual basis. At first, it was suspected that tailings or other contaminated material from the mill site had been used in the construction of this building. However, extensive surveys of the building proved that this was not the case, but rather that the activity was in the concrete block walls of the building. The gamma exposure rate throughout the building was also elevated, increasing near the walls. Further investigation revealed that numerous concrete block buildings in Shiprock, Farmington, Santa Fe, and in Durango, Colorado, also contained block having elevated gamma exposure rates. The details of pumice block production, use, and distribution are not well known at this time although it is understood that pumice is shipped widely throughout the southwestern United States.

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* In this report, the term "radon" refers to radon-222.

** The working level is defined as any combination of radon daughters in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

In 1976, the New Mexico Environmental Improvement Agency (EIA) (now the Health and Environment Department) requested that ORP-LVF conduct a survey of block buildings in the Santa Fe area in order to further evaluate any potential radiation exposures, and to provide them with information to assist in a decision as to whether EIA regulation of the pumice, or the block products made from it, was necessary.

SURVEY METHODS

Instruments for measuring the radon daughter concentrations (in units of working level) were loaned to the EIA. These instruments, formally known as the RPISU (Radon Progeny Integrating Sampling Unit), are designed to measure the alpha particle energy from airborne radon progeny, or daughters. This alpha energy is then converted to working level units, a commonly-used measure of the health hazard from the radon progeny. Unlike most working level samplers, the RPISU measures the average, or integrated, working level over a period of days, rather than taking an instantaneous reading.

A small pump pulls air through the detector head, which consists of a millipore filter in close proximity to two TLD chips. The particulate radon daughters are trapped on the filter paper. As the short-lived daughters decay, their alpha energy is deposited in the thermoluminescent dosimeter, or TLD, adjacent to the filter. A second TLD, shielded from the filter by a metal washer, responds to the more penetrating gamma radiation from external background. The reading on the second (gamma) TLD is subtracted from that on the first one (the alpha TLD) to give a net reading due to alpha energy from the filtered radon daughters.

The TLD material has the property of absorbing radiation energy, then emitting a proportional amount of light when it is heated later under controlled conditions. Therefore, the detector heads are sent back to the EPA laboratory, where they are taken

apart, the TLD's removed, and "read out" in a special instrument to measure the amount of emitted light, and consequently the amount of radiation energy, absorbed during the sampling period. Knowing the radiation energy absorbed and the volume of air sampled, the average working level during the sampling period can be calculated.

Samples were collected in nine buildings in the Santa Fe - Espanola area selected by the EIA staff. The selection criteria were a) that the building be known to be of pumice block construction, and b) that the owner/occupant be willing to participate in the study by allowing the sampling units to be operated in the building.

Seven of the nine buildings were residences and two were office buildings. Five of the structures, identified as Locations #50, 53, 56, 57, and 58 in Tables 1 and 2, were in Santa Fe (elevation 6,900 feet), while four (#51, 52, 54, and 55) were in the Espanola area (average elevation about 5,600 feet). Locations #55 and 58 were the office buildings, which had refrigerated air conditioning. None of the residences had air conditioning. One house (#53) was of frame/stucco construction and was selected as a background house. In the remaining buildings, all or most of the walls were constructed of block containing pumice.

Location #54 was sampled more intensively than the other houses because different parts of it had been constructed of different materials, as shown in Table 2. It was thought that samples from different rooms of this house might provide relative indications of the working levels originating from the different types of construction materials. The pumice block and adobe slump block rooms had just been built when this survey was made, and these rooms were not finished, although they were completely enclosed. The doors, windows and roof were in place; however, the concrete floor had not yet been poured. The room built of adobe slump block was closed off entirely from the rest of the house at the time the samples reported here were taken.

Sampling times of about one week (approximately 168 hours) were proposed. This was not always attained and the actual sampling times ranged from extremes of 33 hours to 628 hours. A total of 33 valid samples were collected during the period June 7, 1976 through May 20, 1977.

During May 1976, gamma exposure rate measurements were made in the selected buildings using a Reuter-Stokes Model RSS-111 Pressurized Ionization Chamber (PIC) and a Baird-Atomic Model NE-148A scintillometer. Readings were taken in the center of each room of the houses, and an outdoor reading was taken to serve as background. The type of construction material and the heating/cooling system for each building was recorded.

Samples of the unprocessed pumice from two commercial pits near Santa Fe and samples of two block products were collected and analyzed for the naturally-occuring radionuclides. The product referred to in this report as "pumice block" resembles a standard concrete block and had dimensions of 8" x 8" x 16". The block referred to as "adobe slump block" is colored and cast with an irregular surface to resemble authentic adobe bricks. These blocks are cast in a variety of sizes and shapes, and are widely used in masonry construction because of their desirable visual effect. The block which was sampled measured 4" x 8" x 16". According to the block manufacturer, the adobe slump and the pumice blocks contain 40 and 65 percent pumice respectively.

RESULTS AND DISCUSSION

The individual working level results for the Santa Fe area are shown in Table 1.

The working level values are calculated to five decimal places, resulting in three or four significant figures for these particular values. When the values are averaged (e.g., in Table 2), the last figure is dropped, which is more indicative of the accuracy and precision of the measurement system.

TABLE 1. INDIVIDUAL WORKING LEVEL RESULTS FOR STRUCTURES IN THE SANTA FE-ESPANOLA AREA

Location and Run #	Date Start	Date Finish	Sampling Time (Hours)	Working Level
50-01	06/07/76	06/15/76	165.3	.00283
50-02	09/22/76	09/30/76	39.3	.00869
50-04	05/18/77	05/20/77	33.1	.00675
51-01	06/07/76	06/16/76	211.5	.00182
51-02	07/26/76	08/02/76	33.9	.00133
51-03	03/07/77	03/14/77	239.1	.00233
52-01	06/16/76	06/22/76	146.7	.00310
52-02	03/14/77	03/21/77	70.5	.00200
53-01	06/15/76	06/22/76	169.1	.00255
53-02	08/17/76	08/24/76	55.7	.00228
53-03	01/17/77	02/03/77	384.4	.00392
54-01Y	07/01/76	07/15/76	326.5	.01559
54-01W	12/16/76	12/23/76	155.9	.01719
54-01X	12/07/76	12/14/76	150.1	.01884
54-02X	04/27/77	05/11/77	339.5	.00985
54-02Y	12/07/76	12/14/76	150.2	.01511
54-03Y	12/16/76	12/23/76	155.8	.01039
54-04Y	12/23/76	12/28/76	121.1	.01346
54-05Y	04/11/77	04/17/77	131.0	.00853
54-01Z	12/23/76	12/28/76	121.0	.01379
55-01	07/15/76	07/26/76	197.5	.00616
55-02	08/02/76	08/09/76	100.9	.00790
55-03	02/28/77	03/04/77	97.4	.00263
55-04	03/28/77	04/04/77	143.9	.00198
56-01	07/06/76	07/27/76	254.6	.00276
56-02	10/13/76	10/15/76	48.4	.01569
57-01	08/26/76	09/21/76	628.3	.01068
57-02	01/06/77	01/17/77	269.2	.00870
57-03	03/04/77	03/13/77	210.5	.00563
57-05	04/13/77	04/18/77	120.0	.00660
58-01	07/27/76	08/17/76	501.4	.00150
58-02	10/26/76	11/05/76	237.1	.00227
58-03	12/30/76	01/17/77	385.0	.00349

TABLE 2. SUMMARY OF WORKING LEVEL RESULTS AND PERTINENT PARAMETERS FOR STRUCTURES IN THE SANTA FE - ESPANOLA AREA

Location	Number of WL Measurements	Average WL (Gross)	Average WL (Net)*	Average Net$^{\phi}$ Gamma Exposure Rate (μR/hr)	Construction Material	Remarks
50	3	0.0061	0.0032	2.1	Pumice block	
51	3	0.0018	-0.0011^{+}	2.4	Pumice block	Block walls reportedly filled with pumice insulation
52	2	0.0025	-0.0004^{+}	1.6	Pumice block	
53	3	0.0029	-0-	0.6	Frame/stucco	Background house
54 W	1	0.0172	0.0143	1.0	Original adobe	
X	2	0.0143	0.0114	2.0	Pumice block	
Y	5	0.0126	0.0097	3.0	Adobe slump block	
Z	1	0.0138	0.0109	0	Frame/stucco	
55	4	0.0047	0.0018	1.5	Adobe slump block	Office building with refrigerated A.C.
56	2	0.0092	0.0063	0.5	Pumice block/ frame	Apartment-common walls of block, others frame
57	4	0.0079	0.0050	2.6	Basement-pumice block Upper story-frame	Samples collected in basement
58	3	0.0024	-0.0005^{+}	Not measured	Pumice block	Office building with refrigerated A.C.

* Obtained by subtracting the average WL from Location #53 from the gross average WL at the other locations.

\+ Negative net WL values were obtained because the "background" WL was larger than the measured WL at these locations.

ϕ Obtained by subtracting outdoor gamma exposure rate from average (or individual room, in case of Location 54) indoor gamma exposure rate. The exposure rates reported here were measured with a pressurized ionization chamber.

As mentioned above, minimum sampling times of one week were proposed. This is derived from the Grand Junction experience, where a minimum sampling time of 100 hours was required in order for a sample to be considered valid for averaging into the annual average working level estimate. The reason for this requirement was to avoid the possibility of including samples collected under non-representative conditions (e.g., unusual ventilation conditions or abrupt weather changes) which might unduly bias the average working level. Samples of less than 100 hours duration were sometimes included in the average by time weighting all samples in the series, rather than using the usual arithmetic average. It was felt that this method would avoid undue bias from the "short" samples.

Due to various operational problems in this study, a few of the samples were considerably short of the 100-hour goal. Both time-weighting and arithmetic averaging were tried with the data in Table 1. In only two cases (Locations 50 and 56) were significantly different results (25-50 percent lower) obtained by the time-weighting method. Therefore, because of the relatively small number of total samples, the "short" samples were retained, and the arithmetic average was used for all locations.

Table 2 summarizes the following Santa Fe area data: gross average working level at each location; the "net" average working level, obtained by subtracting the presumed background working level from the gross working level at each of the other locations; and the net indoor gamma exposure rate, obtained by subtracting the outdoor gamma exposure rate from the average indoor gamma exposure rate. (Outdoor gamma exposures varied from 11 to 16 μR/hr, with a mean and standard deviation of 14.6 ± 1.6 for the eight locations measured.) Table 3 shows the analytical results for the two pumice and the two block samples.

TABLE 3. RADIONUCLIDE CONTENT OF PUMICE AND BLOCK

Concentration (pCi/gram ± two-sigma counting error)

Sample	U-238	U-234	U-235	Th-230	Th-232	Ra-226
Pumice #1	5.4 ±1.1	5.5 ±1.1	0.23 ±0.64	5.2 ± .36	4.0 ± .32	6.1 ± .45
Pumice #2	5.5 ±1.2	5.6 ±1.2	0.18 ± .056	4.2 ± .28	3.7 ± .27	5.6 ± .43
Adobe Slump Block (40% pumice)*	1.7 ± .15	1.6 ± .15	.056± .010	1.4 ± .057	1.2 ± .054	2.2 ± .28
Pumice Block (65% pumice)*	2.8 ± .18	2.2 ± .069	.18 ± .019	<0.042**	.022±.0063**	3.4 ± .34

* As reported by manufacturer

** Thorium analyses believed to be in error on this sample

The data in Table 3 show that the radionuclide content of the pumice is definitely higher than normal background levels, which are generally in the approximate range of 0.5 to 2 pCi/gram for most common mineral building materials. The nuclide concentrations in pumice from the two pits are not statistically different, and the uranium chain radionuclides are approximately in equilibrium.

The radionuclide concentrations in the block products are not greatly different from the normal background levels mentioned above, although the radium-226 values are at the upper end of this range. The radionuclide concentrations in the two types of block are 30 to 50 percent lower than those which would be calculated from the manufacturer's stated percentage of pumice in the block. This may be due to the fact that the data in Table 3 are on a weight basis, whereas concrete mix is usually proportioned on a volume basis. Since the pumice has a lower density than the sand and gravel aggregates, activity in the pumice would therefore account for a lower percentage of the total activity on a weight basis.

In general, the working level results were quite varied. Some correlation exists between working level and indoor gamma exposure rate. Very little correlation exists between working level and type of pumice block or other construction material in the building, the type of ventilation system, or the geographical location. These various items are discussed in more detail below.

In Figure 1, the average gross working level at each location is plotted as a function of the net indoor gamma exposure rate. (The data from two buildings in Shiprock are included in this figure; see the discussion under Other Data below.)

The data points, except for location 56, were fitted with a line (RL-2) by linear regression analysis. Line RL-1 was fitted

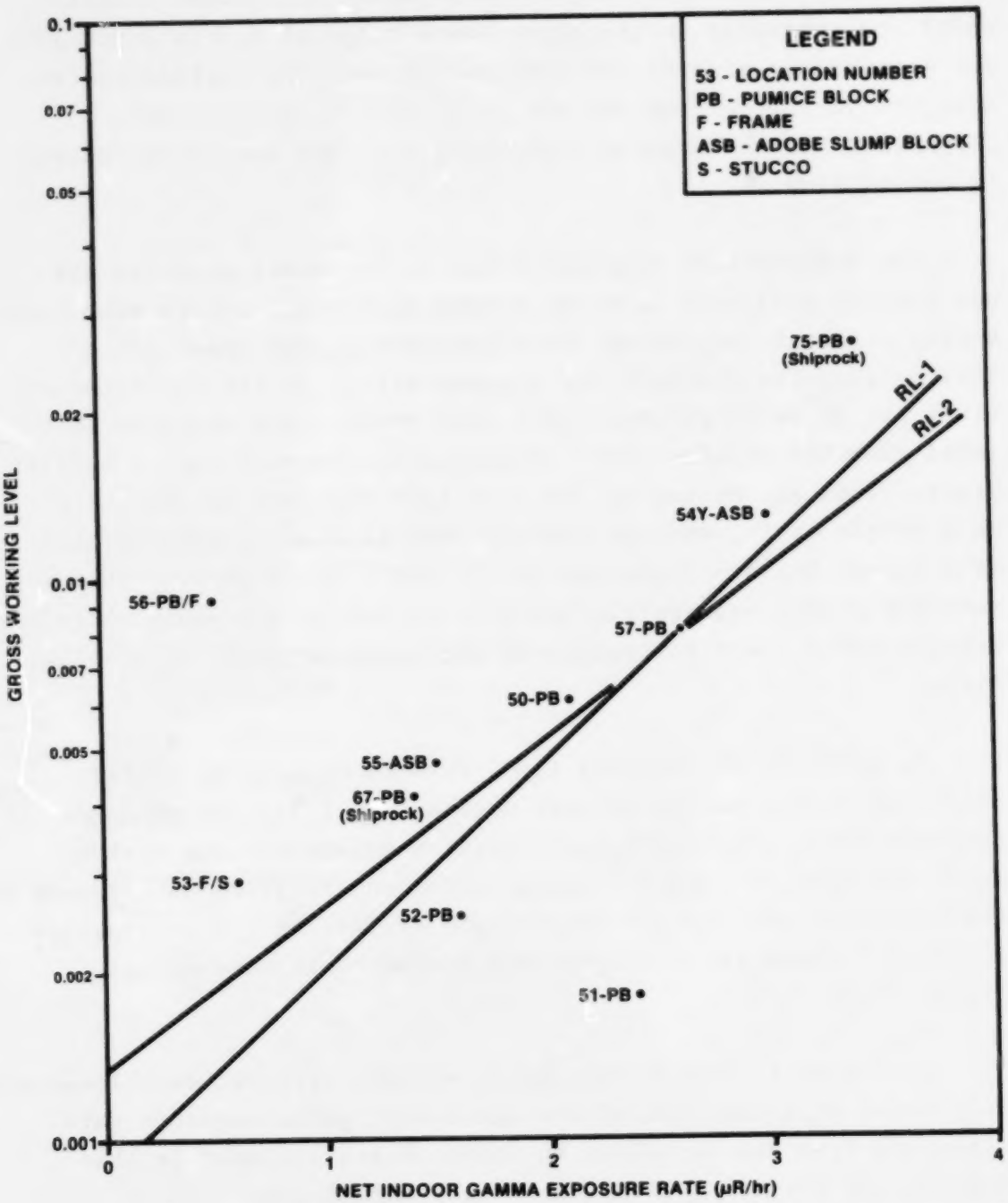

Figure 1. Gross indoor working level vs. net indoor gamma exposure rate

through all of the data points except those for locations 56 and 53. Location 56 was deleted from the analysis because its gamma ray background measurement (taken outdoors) was probably increased by a block wall near the measurement location. Location 53 was deleted because it contained no pumice block. It appears, from the available data for this area, that the gross working level in structures containing pumice block may approach a value of 0.01 WL when the net indoor gamma exposure rate is approximately 3 μR/hr. Lines RL-2 and RL-1 have correlation coefficients of 0.72 and 0.73 respectively, which indicates a "fair" fit to the data points.

Three of the nine structures containing pumice block (two houses and one office building) had average working level values lower than the frame/stucco house which was selected as a background location. Location #51, which had one of the highest net gamma exposure rates measured, and was constructed entirely of pumice block, was one of these. Location #54, the house which contained several different construction types, produced the highest working level results measured in the Santa Fe area. The working levels were quite uniform from room to room in this house, and did not seem to be influenced by the construction material of the room sampled, although the gamma exposure rate definitely was. Three pairs of concurrent samples were collected in this house during December 1976. One sample from each pair was collected in the adobe slump block room, and the other sample from rooms having each of the other three types of construction (see Table 1). Perusal of Table 1 leads one to suspect that the seasonal effect on working level overrides the effect due to construction material in this house, although the data points are insufficient to demonstrate this conclusively. These results appear to indicate that, given a radon source within a house, the working levels throughout the house are relatively uniform, regardless of the location(s) of the source.

Since the pumice block has higher radionuclide levels than does the adobe slump block, one would expect buildings made of it to have higher working levels. The data, however, show that this is not consistently the case. For example, the three structures having an average working level lower than the "background" house were all built of pumice block. The background house, of frame and stucco construction, was selected as background because it contained no block having elevated radioactivity concentrations.

Neither geographical location nor elevation has a discernable effect on the measured working levels. Both the highest and lowest levels were found in the Espanola area, with the structures in Santa Fe falling in between.

Several factors come to mind which might influence the working level in buildings of different construction, or contribute to the apparent variations observed. Frame houses, particularly those in Santa Fe with its cold winters, are probably insulated. Some insulation materials, such as rock wool, are known to be manufactured from slag which may have elevated radium levels, and are therefore a source of radon. The significance of this source is not presently well-known. Frame house interiors are also covered with either plaster or sheet rock (dry wall), both of which contain gypsum which may have slightly elevated radium levels.

The working level in houses having internal radon sources has generally been found to show a seasonal variation, increasing in the winter and decreasing in the summer. The summer reduction may be due to increased ventilation for cooling, which increases the rate of removal of radon and its daughters from the house. To investigate this effect in this case, the data for all locations were summarized by month, and the mean WL was plotted as a function of time of year. The typical seasonal variation is not readily apparent from this plot. Undoubtedly there are an insufficient

number of data points available to expect a valid evaluation of this variable, considering the other potential variables involved.

OTHER DATA

Other information relating to the pumice situation has been collected by ORP-LVF. Some data have been collected specifically to evaluate the pumice situation; other data have been collected during surveys of buildings related to inactive uranium mill sites, as discussed in the Introduction. The two towns where pertinent samples have been collected are Farmington and Shiprock, New Mexico. These two sets of data are discussed separately.

Shiprock

Table 4 summarizes the following Shiprock area data: gross average working level at each location; the 'net' average working level obtained by subtracting a working level from a nearby structure having no pumice used in its construction; and the net indoor gamma exposure rate.

The pumice block building in Shiprock which initiated the investigation of the problem has had continuous WL measurements made in it for over one year. This building (location 75) is close to location 76 and both are sometimes immersed in the radon-222 plume from the tailings piles on the former Shiprock uranium mill site. Because of the relatively large distance between the locations and the tailings piles (approximately 760 m), both are subject to the same radon-222 concentrations from the plume. The average net WL for location 75 was determined by subtracting the average gross WL for location 76 from it. In order to estimate tailings pile radon contribution to the average gross WL for location 75, the average gross WL for location 73 was subtracted from location 76. The adjusted WL for location 76 was then subtracted from location 75. The adjusted gross WL results for location 75 was 0.26 WL and is plotted in Figure 1.

TABLE 4. SUMMARY OF WORKING LEVEL RESULTS AND PERTINANT PARAMETERS FOR STRUCTURES IN THE SHIPROCK, NEW MEXICO AREA

Location Number	Number of WL Measurements	Average WL (Gross)	Average WL (Net)*	Average Net Gamma Exposure Rate μR/hr	Construction Material	Remarks
73*	3	0.0031	---	No data	Metal building	Industrial-Near Location 67
67	7	0.0041	0.001	1.4	Pumice block	Public building
76*	3	0.0094 (0.0063)**	---	No data	Frame building	Near Location 75
75	13	0.032 (0.026)**	0.023	3.4	Pumice block	Training building
68*	5	0.0025	---	No data	Frame & metal	House trailer near Location 71
71	5	0.0048	0.0023	No data	Pumice block	Business

* Locations 73, 76, and 68 are backgrounds for each of the three location pairs listed.

** Gross average working level adjusted for radon from the tailings pile.

Locations 73 and 67 are constructed from different types of materials and WL samples were selected to cover approximately the same time periods for comparison. Very little difference in their WL values was observed, even though location 67 is constructed from pumice block. The reason for this may be that location 67 is subject to heavy outside personnel traffic which results in increased dilution of the indoor air.

Locations 68 and 71 are close to each other and are also subject to the tailings pile radon-222 plume. Although location 71 is constructed from pumice block, its average gross WL is relatively low. The reason for this is that it is a fast food establishment and is subject to heavy traffic like location 67. The detailed WL data for Shiprock are not included in this report, as they will be published elsewhere.

Farmington

A preliminary working level screening survey was made of buildings in Farmington during the period April 6 through July 19, 1976. The samplers were operated by EIA staff based in Farmington, and the sampling had to be terminated by EIA in July because of the press of other duties at that time. Samples were collected in 10 buildings, as shown in Table 5. No gamma exposure rate measurements were made in these buildings to confirm that they were constructed from block containing pumice except for location 900. The use of pumice block at this location was confirmed with a gamma scintillometer survey meter. The working level data are summarized in Table 6 with a description of the use and type of construction material for each building. None of the buildings had refrigerated air conditioning. Because of the paucity of the data, and in the absence of gamma surveys for some degree of confirmation, no "background" value has been assumed for Farmington. As before, considerable variation of working level within construction type was observed. The lowest single value measured was in a block structure, and the highest was in a frame/stucco

TABLE 5. INDIVIDUAL WORKING LEVEL RESULTS FOR STRUCTURES IN FARMINGTON

Location	Date Start	Date Finish	Sampling Time (Hours)	Working Level
900-01	04/06/76	04/08/76	32.6	.00829
900-02	04/08/76	04/15/76	95.4	.00428
900-03	04/15/76	04/19/76	97.9	.00537
901-01	04/09/76	04/11/76	28.8	.00254
901-02	04/12/76	04/16/76	57.5	.00160
901-03	04/16/76	04/21/76	28.7	.00263
901-04	04/21/76	04/26/76	30.5	.00365
901-05	04/26/76	04/29/76	33.5	.00232
902-01	05/04/76	05/13/76	201.1	.00463
903-01	05/19/76	05/31/76	271.6	.00338
904-01	05/19/76	05/31/76	290.5	.00906
905-01	06/06/76	06/14/76	194.8	.00232
906-01	06/15/76	06/18/76	67.8	.00220
906-02	06/21/76	06/29/76	152.3	.00256
907-01	06/21/76	06/29/76	190.7	.00415
908-01	06/29/76	07/06/76	143.0	.00313
909-01	07/06/76	07/19/76	210.2	.00239

TABLE 6. WORKING LEVELS IN FARMINGTON BUILDINGS

Location Number	Number of WL Measurements	Gross WL Measured*	Type of Building	Construction Material
900	3	0.0060	Office	Pumice block
901	5	0.0025	Residence	Block**
902	1	0.0046	Residence	Adobe
903	1	0.0034	Residence	Frame/stucco
904	1	0.0091	Residence	Frame/stucco
905	1	0.0023	Residence	Frame/stucco
906	2	0.0024	Office	Block**
907	1	0.0042	Swimming Pool	Block**
908	1	0.0031	Residence	Frame/stucco
909	1	0.0024	Commercial	Red brick

* This is the arithmetic average at locations where more than one sample was collected

** These buildings are assumed to be pumice block, but were not confirmed with gamma surveys (see text).

TABLE 7. AVERAGE GROSS WORKING LEVEL BY TYPE OF CONSTRUCTION MATERIAL

Construction Material	No. of Locations	No. of Samples	Average WL
Santa Fe - Espanola (excluding #54 and 56, which had mixed construction materials)			
Pumice block *	6	18	0.0042
Frame/stucco	1	3	0.0029
Farmington			
Pumice block	4	11	0.0038
Frame/stucco	4	4	0.0036
Brick	1	1	0.0024
Adobe	1	1	0.0046
Combined			
Pumice block*	9	25	0.0040
Frame/stucco	5	7	0.0032

* Includes adobe slump block

building. It should also be pointed out that these data do not represent an annual average, since all the samples were collected during the spring and early summer, and would therefore be expected to be lower than winter samples.

The average working level, by type of construction material, has been summarized in Table 7 for the Santa Fe - Espanola area, for Farmington, and for the two areas combined. Buildings containing more than one major material were deleted from this summary. The number of locations and of samples for each type of construction material is also shown. While the Farmington and Santa Fe data are not strictly comparable for a number of reasons, the average WL value in the two major types of construction sampled (pumice block and frame/stucco) are quite close together and probably are not statistically different, considering the working level ranges observed within a given structure and between structures of the same type construction. Furthermore, the difference in working level between the two types of construction for the combined areas is also probably not statistically significant.

COMPARISON OF RESULTS WITH STANDARDS

Historically, the only U.S. standard for radon progeny levels in residential or commercial buildings has been the Surgeon General's Grand Junction guidance for houses containing uranium mill tailings. This guidance is summarized as follows:

Annual Average Net WL	Recommendations
Less than 0.01	No action indicated
0.01 - 0.05	Remedial action may be suggested
Over 0.05	Remedial action indicated

Although this guidance gives some perspective, the present data cannot be compared to it directly for several reasons. These are:

1. The Surgeon General's guides were promulgated for use in a specific situation only, which is different from the pumice block situation.

2. Reliable background data are not available for the present situation. It seems evident that the measured working levels are influenced by variables other than the one under investigation, thus making the selection of a valid "background" location(s) difficult.

3. The annual average working level for most of the Santa Fe/Espanola locations is questionable, since the samples were generally too few and/or too erratically spaced over time. Although the annual average for individual locations may therefore be questionable, it should be noted that the total number of samples were fairly well distributed over the year.

CONCLUSIONS AND RECOMMENDATIONS

1. The results from this screening survey are insufficient to allow definite conclusions to be drawn regarding the potential health hazards which may result from the use of pumice in building block. There is some indication that the use of pumice block may increase the working level in the structure. However, this effect is so small that it is difficult to separate it from the variations in background and from the variability caused by other parameters.

2. Specific unanswered questions include the definition of "background" working level, the definition of the

annual average working level in most of the buildings measured, and an evaluation of other parameters which possibly (or probably) affect indoor working levels. These include the ambient radon concentration from natural sources and its variability, other possible radon sources from other building materials (e.g., rock wool insulation), specific ventilation practices in individual buildings, etc.

3. Gamma exposure rate measurements inside a building appear to give some indication of the measured working level, to the extent that gamma surveys could be used as a screening tool.

4. All the working level measurements which have been made are in the categories of "No action indicated" or "Remedial action may be suggested" under guidance which has been promulgated by the Surgeon General, although this guidance is for use in a different situation, as discussed above.

5. On the basis of the data currently available, it does not appear that either remedial action or licensing of the pumice material is immediately warranted. However, it is recognized that use of the pumice in construction materials is widespread, and although individual exposures may be small, the potential aggregate population exposure may be sufficiently significant to warrant consideration for control in the future.

6. Because any increase in working level due to pumice block use is small, a sampling program to establish a meaningful numerical value for the increase would have to be quite extensive, involving more locations,

samplers, and samples than this screening survey. It would also have to be much more comprehensive in order to provide a satisfactory definition of the variables described above.

7. An adequate population dose assessment for the pumice use would require, in addition to the sampling mentioned above, more information than is currently available regarding the use and distribution of the pumice block, e.g., the number of structures containing it, the types of structures, and their geographical distribution. It would also require a more detailed evaluation of the variability of the radioactivity content of pumice from different pits and different places within the pits.